(12) UK Patent Application (19) GB (11) 2 145 877 A

(43) Application published 3 Apr 1985

(21) Application No 8322956

(22) Date of filing 26 Aug 1983

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(51) INT CL⁴
H01G 5/22 B41J 5/10 H03K 17/98 // H01G 5/24 H03K 17/96

(52) Domestic classification
H1M 2A 2P4 BU CJ
B6F CP
G1N 17TR 19B2B
U1S 2028 2123 B6F G1N H1M

(56) Documents cited
GB A 2101329 GB 1582640 EP A1 0039231
GB A 2073952 GB 1443174

(58) Field of search
H1M
G1N
B6F

(54) Improvements to capacitive keyboards

(57) The invention relates to capacitive keyboards in which a finger, or a key (1) carrying a moving electrode (2), is associated with two fixed electrodes (3_1, 3_2) placed on opposite sides of an insulating foil (4) but not overlapping one another, these fixed electrodes being capacitively coupled when the moving electrode or finger is brought close to them. A third fixed electrode (3_3) can be provided.

The insulating foil is made of one at least of the polymers and copolymers of a substance selected from the group constituted of the mono-, di- and trifluoro ethylenes, preferably of polyvinylidene fluoride.

FIG.1.

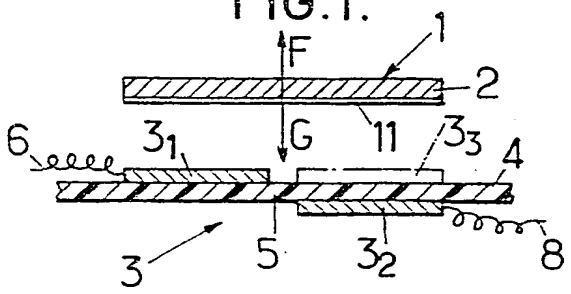

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FIG.1.

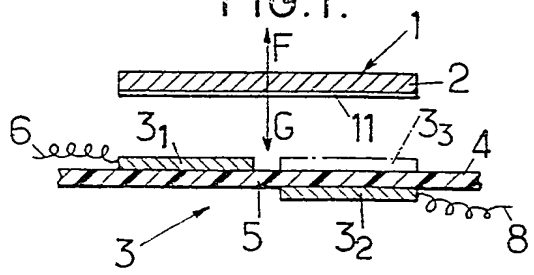


FIG.2.

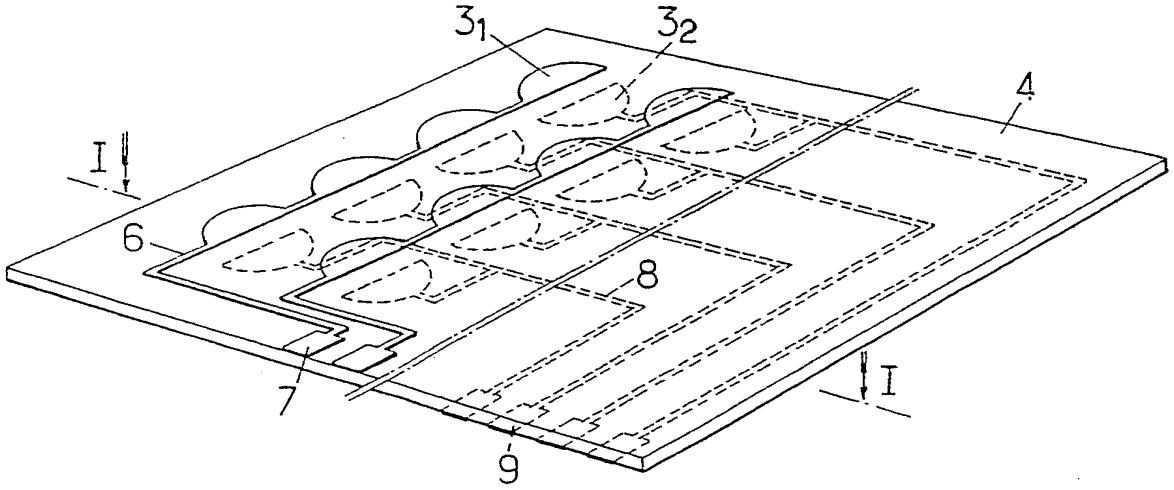


FIG.3.

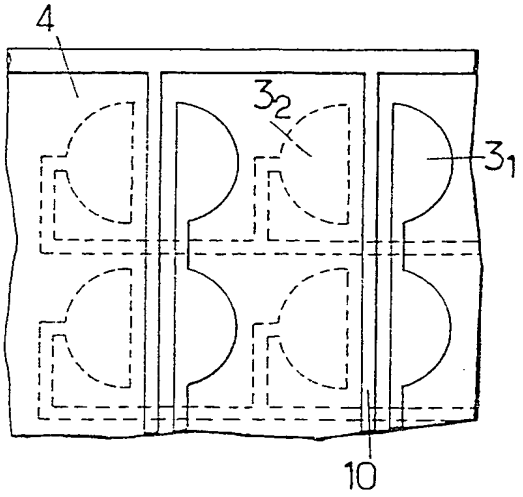
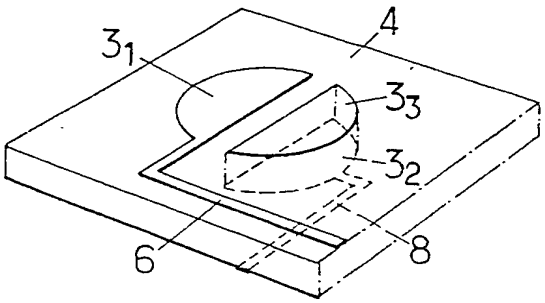


FIG.4.



SPECIFICATION

Improvements to capacitive keyboards

The invention relates to capacitive keyboards of the matrix type that is to say to electrical circuits which are supposed to provide a plurality of distinct orders when the various keys of a keyboard are being depressed, these circuits including a matricial arrangement of points each being associated to a key of the keyboard and obeying the same repartition in rows and in columns than the keys, each of this points being itself composed of two fixed electrically insulated electrodes, which can be capacitively coupled one with the other by the simple depressing of the associated key, this depressing of the key having the effect of bringing close to these fixed electrodes a moving electrode also associated to said key.

The applications of these keyboards are various: they allow the introduction in computers of the input data, associated with the various keys, which can be of all forms, for instance letters or numbers of operations to be done . . .

In these keyboards the fixed electrodes are electrically arranged along the rows and the columns of a matrix in such a way that pressing the key located at the intersection of row i and column j of the keyboard electrically connects the i input of the keyboard to its j output.

For this purpose all fixed electrodes of the same type, for instance those on the left hand side are connected together along rows, each lead line for the connection of a row being itself connected to one input of the keyboard and all the fixed electrodes of the other type (here on the right hand side) are connected together along columns, each lead line for the connection of a column being connected to an output.

The electronic circuitry needed by such a keyboard includes means for generating electrical signals successively on said inputs and means for detecting such signals at said outputs. When the keys are not activated the electrical energy received at the outputs when such signals are emitted is very weak and only due to stray capacitors. On the contrary when a key is depressed, a strong capacitive coupling is achieved between the line and the column associated with the depressed key, which in turn produces a strong increase of the electrical energy transmitted towards the corresponding output.

The various lead lines associated to the rows and columns have many crossing points but they must be electrically insulated one from the other.

In order to fulfill such an insulation, the two arrays of lead lines associated respectively to the rows and the columns are placed on the two opposite sides of an insulating plate such as a printed circuit board on one side only of which the fixed electrodes have been placed.

This requires to drill and metallize many holes in the board in order to electrically connect to the corresponding fixed electrodes the lead lines which are not placed on the same side of the board as the fixed electrodes.

In an improved design such as disclosed in US Patent n° 3 921 167, the lead lines of each array and the fixed electrodes connected to these lead lines are being placed on the same side of an insulating member, the members associated with the two arrays being distinct and being pressed one against the other with their lead lines oriented one towards the other, an insulating foil being interposed between them.

In this case, the capacitive coupling between the two fixed electrodes associated to the same key is not directly made through the moving electrode but also through the insulating foil and twice through the insulation member located one the side of said moving electrode.

This avoids to drill in the board and metallize the holes which perform the multiple electrical connections through the board but the capacitive coupling is made through three thicknesses of low dielectric permittivity insulating foil. By "permittivity" we mean here and in the rest of this text the relative permittivity that is to say the value of this quantity expressed by reference to that of vacuum.

In another improved design such as disclosed in GB Patent n° 1 582 640, the lead lines of each array and the fixed electrodes connected to these lead lines are being placed on the two sides of an insulating plate, of the type of those being used to make printed circuit board, which have thicknesses over 1 mm and permittivity of the order of 2.

In these two improvements the fixed electrodes are respectively placed against the two opposite sides of the same insulating foil, in such position that the projection of one the electrodes in the plane of the other electrode along the direction perpendicular to this plane is located next to this other electrode at a small distance from it.

These two improvements exhibit however the great inconvenience to insure the capacitive coupling through one or many condensers in series, each having a small value, typically smaller than 5 pF, which has the effect of creating a very weak coupling between the lines and the columns when the keys are being depressed.

The exploitation of such small variations of capacitance is difficult and requires the use of sensitive circuits and even of compensating circuits. Another disadvantage of the small variation of coupling and thus of the very sensitive detection circuitry is the strong sensitivity mof the general keyboard to electromagnetic interferences.

The inventors have observed that all these inconveniences are suppressed when the insulating foil is made of one at least of the polymers and copolymers of a substance selected from the group consisting of the mono-, di- and trifluoroolefins of the ethylene family. These substances are the polyvinyl fluoride ($-CHF-CH_2-$), the polyvinylidene fluoride ($-CH_2-CF_2-$) and the polytrifluoroethylene ($-CHF-CF_2-$). These materials have dielectric permittivities of the order of 10 and even more, particularly after mechanical stretching and or electrical poling under high electric field, of the order of 10 kV/cm or more.

The insulating foil has in preferred embodiments a relatively small thickness for instance fifty microns.

The small thickness and the high permittivity result in the fact that the value of the capacitor formed between the moving electrode in its position of high capacitive coupling and the electrode situated on the other side of the insulating foil is relatively high: if one assumes that the surface of each fixed electrode is generally of the order of 0.5 cm^2, the said capacitor, in which the dielectric is made by the insulating foil, is in general of a value larger than 50 pF and typically of the order of 100 pF.

In these conditions, the total capacity between the two fixed electrodes associated to a same point is:

–practically zero, typically smaller than 2 pF when the key is not being depressed and the moving electrode is far away from the two fixed electrodes,

–and on the contrary, very high when this moving electrode is being placed in its coupling position, said total capacity corresponding to the combination in series of the just analyzed larger capacity and of that formed by the moving electrode and the fixed electrode located on the side of the moving electrode.

In preferred embodiments, recourse is had furthermore to one and/or the other of the following arrangements:

–the insulating foil is made of polyvinylidene fluoride or in one of its copolymers,

–the insulating foil is made of polyvinylidene fluoride or in one of its copolymers, after mechanical stretching and/or electrical poling under high electric field,

–the fixed electrodes are placed on the two sides of the insulating foil,

–the moving electrode is, according to the preceding item, covered on its side, oriented towards the fixed electrodes with a thin insulating layer,

–the moving electrode according to the preceding item is made of aluminium and is covered on its side oriented towards the fixed electrodes with a thin layer of aluminium oxide,

–the insulating layer, according to the item which precedes the preceding is made with a high permittivity polymer foil, for instance a small thickness polyvinylidene fluoride foil, the moving electrode being for instance a metallization of the side, of this foil, the furthest of the fixed electrodes,

–the fixed electrodes are placed on insulating members placed on the two sides of the insulating foil, on the side of these members oriented towards the insulating foil,

–the insulating member according to the preceding item, located on the side of the moving electrode is made with a high permittivity polymer foil, for instance of a small thickness polyvinylidene fluoride foil, the moving electrode being for instance a metallization of the side, of this foil, the closest to the insulating foil.

The invention includes, apart these main arrangements, other arrangements which are used preferably at the same time and which will be more explicitly discussed there after.

In what follows, a few preferred embodiments of the invention will be described with reference to the accompanying drawing in a way which is of course in no way limiting.

Figure 1 of this drawing shows a capacitive keyboard according to the invention along a schematical view made at the level of the keys.

Figure 2 shows a perspective view of the insulating foil included in such a keyboard, foil being covered of electrical connections on its two sides according to the invention.

Figure 3 shows a fragmentary view according to a variation of the invention.

Figure 4 shows a fragmentary perspective view of an other variation in accordance with the invention.

The capacitive keyboard includes a matrical arrangement—that is to say rows and columns—of keys schematized by reference 1, each key including a moving electrode 2 and elastic means, not shown, producing a force along the direction symbolized by arrow F, perpendicularly to this electrode, towards a rest position.

To each key is associated a point 3 composed of two fixed electrodes 3_1 and 3_2 electrically insulated one from the other one which can be capacitively coupled when the moving electrode 2 is brought closed to the fixed electrodes along arrow G opposed to arrow F, that is to say against the restoring force produced by the elastic means.

The two electrodes 3_1 and 3_2 are flat and thin and respectively placed against the two opposite sides of the same insulating foil 4 in such position that the projection of one of the electrodes in the plane of the other electrode along the direction perpendicular to this plane is located next to this other electrode at a small distance from it.

The insulating foil 4 is, according to the invention, made of one, at least, of the polymers and copolymers of a substance selected

from the group constituted of the mono-, di- and trifluoro ethylenes.

Each of electrodes 3_1 and 3_2 herein considered can have any shape, for instance, rectangular shape or half circle as illustrated on the drawing; in this last case, the diameters which are delimiting this half circles are parallel to each other and placed in closed proximity one to the other, these diameters and their projection on the opposite face of the foil 4 defining a narrow gap 5 of insulating material interposed between the two electrodes.

These electrodes are being placed against or printed on the foil in any desirable manner with one electrode 3_1 and one electrode 3_2 facing each key 1, all the electrodes against the same side of foil 4 being placed parallel one to the others, along the same matricial arrangement as the keys of the keyboard.

All the fixed electrodes of the type of electrode 3_1 that is to say those which have been placed on the left hand side on the upper side of foil 4 in Figs. 1 and 2, are electrically connected along parallel lines, that is to say columns if one considers Fig. 2 from its lower left hand corner.

These electrical connections are made with lead lines 6 themselves, as electrodes 3_1, placed against the upper side considered on foil 4 and each of those lead lines 6 is itself connected on the side of this foil to an electrode 7 for external connection.

In a similar manner, all the electrodes of the type of electrode 3_2 that is to say electrodes which have been placed on the right hand side against the lower face of foil 4 in the above mentioned example, are electrically connected along parallel lines, that is to say rows, by lead lines 8 themselves connected to lateral connecting electrodes 9.

The widths of the lead lines 6 and 8 are very small in order to minimize the stray capacitors which can appear through the foil at the crossing points of these lead lines.

Since it is very thin, foil 4 is relatively flexible: it can be mechanically reinforced by applying it against any solid insulating plate. This rigid plate can be made in a material much cheaper than that used to make printed circuit boards, particularly those in which the fixed electrodes are placed on the same side of the plates, solution for which one of the fixed electrodes of each point has to be electrically connected to its lead line by plated through holes crossing the board as has been explained above. This rigid plate can also be one of said insulating members.

In order to increase the electrical separation of the two electrodes 3_1 and 3_2 of each point one can advantageously place along the insulating gap 5 which separates them, against one at least of the two sides of foil 4, grounded conductive lines 10 (Fig. 3).

In order to avoid any risk of electrical contact between said lines 10 and electrode 2, when no insulating layer has been placed on the face of this electrode oriented towards the fixed electrode, one can simply place lines 10 on the face of foil 4 which is the further from the moving electrode 2.

When the fixed electrodes which are against the side of the insulating foil which is facing the moving electrode are directly made on that foil, and in order to avoid the troubles which can appear when the moving electrode is badly centered or badly pressed, which could produce a bad contact between this moving electrode and a portion of the surface facing the fixed electrode, it is advantageous to place on the side of foil 4 which is the closer to the moving electrode, beside each fixed electrode 3_1 already placed on this face of the foil, a third fixed electrode 3_3 (Fig. 4) which has the same dimension and the same orientation as the second fixed electrode 3_2 and which is placed at the location of the projection of this second electrode along arrow F on the considered face.

Such a construction avoids the presence of air layers which would be troublesome between the moving electrode 2 and the surfaces against which it is applied when the corresponding key is being pressed, so that the global capacitor for the coupling insured in such a way between the two electrodes 3_1 and 3_2 during such pressing of the key is always maximum.

The operation of the keyboard such as described above is the following.

Pressing key 1 in such a keyboard along the direction of arrow F (Fig. 1) must have the effect of capacitively coupling between them the two fixed electrodes 3_1 and 3_2 and thus lead lines 6 and 8 respectively, which are themselves connected respectively to a source of electrical signal and to a receiver for such a signal.

The electrical connection between the two electrodes 3_1 and 3_2 is insured by capacitive coupling of each of these two electrodes and the moving electrode 2.

The coupling between this moving electrode 2 and the first fixed electrode 3_1 the closer from this moving electrode can be insured by direct mutual contact between these two conductive elements which corresponds to an infinite coupling capacitor.

But if one wants to avoid such a direct mutual electrical contact, which can be the origin of various problems in some cases, one can simply place on one of the two considered electrodes, and preferably on the moving electrode 2, a thin insulating layer 11.

For this purpose, for instance if the moving electrode 2 is made of aluminium, layer 11 can be made by a thin aluminium oxide layer the thickness of which is smaller than a micron: the electrical coupling capacitor made through such a layer is still very high.

One can mention that the insulating layer

11, since it can be placed on a supporting conducting element, can be very thin for instance, thinner than 5 microns or less, and in particular much thinner than an independent foil made for supporting printed circuits.

The insulating layer 11 can also be made with a high permittivity polymer material, the permittivity being preferably of the order of 10 or more.

This foil 11 can itself be very thin since it is not made to support circuits: it is for instance a ten microns thick polyvinylidene fluoride foil.

In this last case, the moving electrode can be made by a metallization of the face of foil 11, the farther from the fixed electrodes.

When the fixed electrodes, against the side of the insulating foil which is the closer to the moving electrode are made on an insulating member, this member avoids the direct electrical contact between the moving electrode and electrode 3_1. This insulating member is preferably of thickness smaller than 50 m and has a permittivity of the order of 10 or more.

In preferred embodiment it is made by polyvinylidene fluoride and replaces the insulating foil 11 above mentioned.

The coupling made between the moving electrode 2 and the second fixed electrode 3_2, the one which is the farther from the moving electrode, is made through foil 4 and eventually through a thin insulating layer 11 if one has been placed there.

The capacity of this coupling is still relatively high taking into account the particular characteristics above mentioned of foil 4: if the permittivity of this foil is of the order of 10 and its thickness of the order of 50 microns, and if the area of fixed electrode 3_1 is of the order of 0.5 cm^2, the capacity is of the order of 100 pF.

Thus the global capacity resulting from the coupling made between the two fixed electrodes 3_1 and 3_2, made out with the two capacitors above described connected in series, is itself very high: it is here larger than 20 pF and even in general than 50 pF, whereas it hardly reaches 10 pF with the improved prior proposals mentioned above.

It must be pointed out that the thin insulating layer 11 can be localized only facing the first fixed electrode 3_1 and can be suppressed facing the second fixed electrode 3_2—and eventually the third fixed electrode 3_3—, some means for compensating the thickness being eventually placed in order to avoid a non parallel contact during a depression of the corresponding key: such a technique allows an increase of the coupling capacity between the moving electrode 2 and the second fixed electrode 3_2.

It should also be pointed out that the insulating layer 11 can be made useless if the fixed electrode 2 is made electrically floating that is to say if it is itself insulated from any permanent external electrical connection: one can notice indeed that in such an hypothesis, even when this moving electrode 2 is in its position for which it insures the capacitive coupling, no direct contact is being established between this moving electrode 2 and the fixed electrode 3_2 and subsequently the simple direct contact between this electrode and electrode 3_1 does not close any electrical circuit.

In such an hypothesis, an insulating layer can be placed on the side of the moving electrode 2 which is opposed to its conducting face thus oriented towards the fixed electrodes, particularly when the displacement of this moving electrode 2 is produced by the direct pressing of finger on it and in order to avoid to put to ground, through the human body of the user, this electrode and the part of the electrical circuit eventually put in direct contact to it through the fixed electrode 3_1.

In this last case, it may be advantageous to make the moving electrode by metallization of an insulating layer, the metallization being oriented towards the fixed electrodes.

One can also produce the moving electrode itself by the skin of a finger coming against the point, this skin coming in direct contact with fixed electrode 3_1 at that point, except if an insulating intermediate foil of high permittivity and small thickness has been placed, this foil being common to all points and being used as a general protection for the keyboard.

This foil can be the insulating member itself on which have been placed the fixed electrodes.

The above keyboards are particularly well fitted for transparent structures. Thin foils of polymers made of a substance selected in the group constituted of the mono-, di- and trifluoroolefins of the ethylene family being optically transparent, they can be used to make the insulation foil and members.

In this case the various electrodes herein described are made by vaccum or chemical deposition of thin layers of transparent conductors such as indium and tin oxides (ITO) on these foil and member.

These processes can heat the substrates on which the deposition is made. For this reason polyvinylidene fluoride is of great interest since it withstands with good stability exceptionaly high temperature.

Following which and whatever the embodiment adopted, a capacitive keyboard is obtained for which construction and operation are sufficiently clear from what has been described.

This keyboard exhibits as compared to those formely known, a certain number of advantages and particularly the great simplicity of fabrication, low cost, improved coupling capacity, simplified electronic circuitry and good resistance to electromagnetic interferences.

As is evident and as results moreover already from what has gone before, the invention is in no way limited to those of its modes of application and embodiments which have been more specially considered; it embraces, on the contrary, all variations.

CLAIMS

1. Capacitive keyboard of the matrix type, providing a plurality of distinct orders when the various keys (1) of a keyboard are being depressed, including a matricial arrangement of points (3) each being associated to a key of the keyboard and obeying the same repartition in rows and in columns than the keys and being itself composed of two fixed electrically insulated electrodes (3_1, 3_2), which can be capacitively coupled one with the other one by the simple depressing of the associated key, this depressing of the key having the effect of bringing close to these fixed electrodes a moving electrode (2) also associated to said key, the two fixed electrodes (3_1, 3_2) being respectively placed against the two opposite sides of an insulating foil, in such position that the projection of one of the electrodes in the plane of the other electrode along the direction perpendicular to this plane is located next to this other electrode at a small distance from it, characterized in that the insulating foil is made of one at least of the polymers and copolymers of a substance selected from the group consisting of the mono-, di- and trifluoro ethylenes.

2. Capacitive keyboard according to claim 1 characterized in that the insulating foil is made of polyvinylidene fluoride.

3. Capacitive keyboard according to claim 2 characterized in that the foil has been mechanically stretched.

4. Capacitive keyboard according to claim 2 characterized in that the foil has been electrically poled in an electric field.

5. Capacitive keyboard according to claim 1 characterized in that the foil has a thickness of less than 50 microns.

6. Capacitive keyboard according to claim 1 characterized in that the fixed electrodes are made on the insulating foil.

7. Capacitive keyboard according to claim 6 characterized in that the moving electrode is covered, on its side oriented towards the fixed electrodes, with a thin insulating layer of the same family as that of the insulating foil.

8. Capacitive keyboard according to claim 1 characterized in that the fixed electrodes are made on at least one insulating member and placed on the side, of this member, oriented towards the insulating foil.

9. Capacitive keyboard according to claim 8 characterized in that the insulating member placed on the side of the moving electrode is made of the same material as that of the insulating foil.

10. Capacitive keyboard according to claim 1 characterized in that its constitutive parts are optically transparent.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1985, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.